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Responses to Trade Liberalization: Changes in Product Diversification in Foreign- and Domestic-Controlled Plants

by John R. Baldwin, Richard Caves and Wulong Gu

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Abstract

This paper studies the impact that a small country joining a regional trade agreement, but particularly a small country, might be expected to gain from the exploitation of scale economies. It makes use of the experience of Canada when it entered into the Canada-United States Free Trade Agreement (FTA) in the early 1990s.

It finds that there was a general increase in the pace of plant commodity specialization around the time of implementation of the Free Trade Agreement. At the time of the treaty, plant diversity was found to be higher in larger plants and in industries with assets that are associated with scope economies. Diversity was also higher in industries that had higher rates of tariff protection.

Over the 1980s and 1990s, plant diversity decreased with reductions in both U.S. and Canadian tariffs. And the decline was greater during the post FTA era than before, thereby suggesting that this treaty had an impact above and beyond that just engendered by the tariff reductions that were associated with it. The study also found that foreign-controlled plants tended to adjust more over the entire period.

Keywords: diversification, trade and product line specialization

JEL codes: 611

Executive summary

This paper studies the impact of the Canada-United States Free Trade Agreement (FTA) on a key aspect of Canada's industrial structure—the level of plant specialization in the manufacturing sector. Plants that produce large numbers of products are less specialized (more diversified) that those producing fewer products. Product diversification at the plant level is a strategy that may be adopted in order to enlarge a plant in order to exploit the economies of large scale plant production. While this may reduce the average costs of production, the strategy may still leave average costs at uncompetitive levels if it leads to short production runs per product. A number of studies have attributed higher Canadian manufacturing costs to shorter production-run length (Safarian 1966, Scherer et al., 1975).

One of the fundamental outcomes that policy analysts had predicted would occur as a result of the relaxation of trade barriers between Canada and the United States was an improvement in Canadian plant size and an increase in production-run length. While little has been found in the way of adaptation of plant size (Head and Ries, 1999), this paper provides strong evidence that the primary influence of the FTA was on production-run length through increased plant specialization. Plant specialization changed dramatically after the implementation of the FTA and this increased the length of the average production run.

This paper investigates plant specialization (or plant diversification) by asking three questions.

1) What changes occurred in the specialization of Canadian manufacturing plants in the 1980s and 1990s?

Tariff rates declined in both the 1980s and 1990s, with the pace of decline picking up in the 1990s as the Free Trade Agreement and the North American Free Trade Agreement were introduced. This paper therefore first examines the evidence that Canadian manufacturing plants as a whole were adapting over this entire period to these tariff reductions by increasing both plant specialization and the length of the production run.

The evidence indicates that there was a downward trend in plant diversification or an increase in plant specialization over the period for both domestic- and foreign-controlled plants. The decline is faster for foreign-controlled plants, particularly before 1988. In the 1970s, foreign-controlled plants are more diversified than their domestic-controlled counterparts. In 1996, the difference in their diversification was quite small.

2) What are the plant and industry characteristics that are related to high levels of diversification (low levels of specialization)?

In order to understand the relationship between a plant's decision to specialize in a small number of products and its relationship to tariffs, the paper then uses evidence taken from observations on individual manufacturing plants and asks whether it is primarily in industries that received higher tariff protection that plant specialization was lower or diversification was higher.

The paper uses a cross-section of observations on the level of diversification of manufacturing plants and multivariate analysis to answer this question. It finds that higher Canadian and U.S. tariff rates are linked to greater plant diversification (less specialization). A number of other plant characteristics were related to diversification. Larger plants tended to be more diversified. Exporters were more specialized than non-exporters thereby suggesting that access to foreign markets obviated the necessity of packing products into plants in order to exploit plant economies of scale.

3) What was the response of Canadian manufacturers to changes in tariffs?

Finally, the paper asks whether changes in the specialization of individual plants were larger in industries where tariffs decreased the most. To answer this question, the paper examines the connection between changes in tariffs and changes in plant specialization over the period. It finds that both Canadian and U.S. tariff cuts led to increased specialization. Second, the decline in product diversification was faster for foreign-controlled plants than for domestic-controlled plants. Moreover, the tariff effect was greater for foreign plants. Foreign-controlled plants were better able to adapt to changes in trade liberalization during the specialization process.

In summary, the paper finds that commodity specialization increased over both the 1980s and 1990s; but the pace of commodity specialization increased around the time of the implementation of the Free Trade Agreement between Canada and the United States. Over the 1980s and 1990s, plant diversity was shown to have decreased most where tariffs fell the most. And the decline was greater during the post-FTA era than before, thereby suggesting that this treaty had an impact above and beyond just the tariff reductions that were associated with it.

1. Introduction

This paper studies the impact that a small country joining a regional trade agreement, but particularly a small country, might be expected to gain from the exploitation of scale economies. It makes use of the experience of Canada when it entered into the Canada-United States Free Trade Agreement (FTA) in the early 1990s.

Diversification has long remained a murky area in our understanding of industrial organization generally and in particular as it affects the efficiency of open economies, which undertake extensive international trade and foreign direct investment but also subjects them to government controls.[1] Diversification is not routinely measured by census takers, leaving us short of both basic facts and research inputs. Economic theory offers certain predictions about where diversification will occur, but these rest on diverse assumptions and analytical bases and point to different normative verdicts. Furthermore, their implications for the small, open economy have not been pulled together. These are particularly important for Canada, hosting extensive foreign direct investment and with a long tradition of heavy protection giving way under the Canada-United States Free Trade Agreement (FTA) and subsequently the North American Free Trade Agreement (NAFTA).

This paper examines diversification levels and changes in Canadian manufacturing plants, chiefly over the period stretching from the 1980s to the late 1990s, during which NAFTA was implemented. It also investigates whether the changes varied between foreign-controlled and domestically-controlled firms.

Changes in the diversification of plants' outputs across commodities reveal how firms have adapted multi-product production to the presence of scale and scope economies at the plant level and changing levels of protection associated with trade liberalization. Changes in the magnitude of plant-level diversification arise from firms' attempts to adapt to changes in underlying production economies. Traditionally, the importance of product-line scale economies provided the foundation for studies of plant specialization. Failure to fully exploit scale economies in the product line was seen to result from high transportation costs (Scherer et al., 1975) due to geographical distance between markets, or from tariff constraints that exacerbated the effects of distance (Eastman and Stykolt, 1967). Baumol et al. (1982) emphasized that scope economies at the plant level can also cause firms to choose to produce multiple products, since the economies of joint production could offset the costs of not exhausting scale economies for each product line.

A study of the level of diversification of plants and changes therein reveals whether the relative importance of scale and scope economies has been changing in face of trade liberalization. It is particularly important in the Canadian context since major changes in trade policy in the late nineteen eighties allow us to examine whether changes in trade policy were associated with changes in plant specialization that led to a narrower range of products. In the late 1980s, the Free Trade Agreement with the United States not only moved to eliminate tariffs but also set in

1. For earlier studies on plant diversification see Caves (1975), Baldwin and Gorecki (1983a), Gollop and Monahan (1991), Streitwieser (1991) and Jovanovic (1993).

place an arbitration procedure that was meant to assure firms of a more stable trading environment.

Economists have made reference to different models to suggest that trade liberalization might be expected to affect production efficiency. In the Canadian literature, the Eastman-Stykolt (1967) model of foreign investment stressed that tariff barriers in a small country with oligopolistic markets could lead to suboptimal plant size. Associated with problems of suboptimal plant size were difficulties arising from short production runs. Harris (1984) formalized a general equilibrium model, applied to the Canadian industrial structure, that examines the effects of trade liberalization on the production process.[2]

Safarian's pioneering survey on the relative costs of foreign multinationals operating in Canada (1966, ch. 7) reported that most foreign affiliates operating in Canada had higher unit costs than parent companies' plants located in the United States. These higher costs were attributed to a variety of sources; but shorter production runs was the most common response for those reporting higher unit costs.

Shorter production runs can arise either from suboptimal plant size or excessive product line diversity. Earlier studies on the Canadian market by Daly et al. (1968) and Caves (1975) investigated evidence that Canadian plants suffered from excessive levels of diversity. Operating behind tariff barriers, Canadian plants were seen to have had production runs that were too short to exploit the economies of large-scale production.

Based on this framework, both the Economic Council (1967, 1975) and the Royal Commission on Corporate Concentration (1978) predicted that the lowering of Canadian tariff barriers would increase Canadian average plant size and that it would reduce product diversity at the plant level and improve the length of production runs.

In this study, we focus on changes that have taken place over time in plant diversification around the time of the introduction of the FTA. We focus on the manufacturing sector since comprehensive and reliable time series data are available for this Canadian sector. We are particularly interested in whether changes in specialization are related to changes in the trade regime facing Canadian industry.

This paper addresses these issues in three steps. The first section organizes theories of diversification and selected empirical evidence in the context of the small, open economy. The second reports on levels of diversification in Canadian manufacturing plants and their changes over 1973-1997. With these materials in hand, we report statistical tests of the association (in levels and changes) between diversification and the exposure of Canadian manufacturing industries to international trade and foreign direct investment.

2. There is also an extensive literature that focuses on the effect of trade liberalization on the price-cost margin (Markusen, 1981; Markusen et al., 1995).

2. Output diversity: Sources and efficiency

2.1 Output diversity at the plant level

Theoretical models of diversification can be divided into those pertaining to diverse outputs of the plant and diverse activities of the firm each of whose plants could nonetheless be specialized. Although our empirical analysis addresses diversification at the plant level, the firm's incentive to diversify demands attention because it can trigger decisions to diversify a plant's output. The central idea is that a value-maximizing firm might profitably market several (diverse) products because it enjoys some sort of scope economies. The scope economies might arise either within the plant or in other activities that the firm undertakes. Examples of the latter include running several goods through a multi-product distribution system subject to economies of scale, or realizing scale economies in sourcing an input used in common to produce several goods. The firm thus might make several products in a single plant either because it enjoys scope economies in production, or because the diverse production warranted by non-production scope economies might be carried out no less economically in one diversified plant than in separate plants. Assume that plants potentially able to turn out diversified products are subject to scale economies in their overall capacities—floor space, common systems and facilities, supervision, etc. It could be cheaper to produce two goods in a single large plant than in two smaller plants. Indeed, this condition could hold even if diseconomies of scope occur within the plant. These could take a number of forms discussed by Skinner (1974).

The possibility that output diversity arises in Canadian plants not from scope economies but despite scope diseconomies is linked to longstanding discussions of Canadian policy that have focused on the status of Canadian manufacturing as an import-competing sector serving a small national market (Eastman and Stykolt, 1967). The equilibrium structure that emerged for many manufacturing industries involved a small (oligopolistic) number of producers charging a price pegged to the tariff-ridden price of imports. This number of sellers could represent what is now called a free-entry equilibrium: each (identical) incumbent earns normal profits, perhaps somewhat more, but the entry of one more firm would make all of them unprofitable. Each firm (plant) would face a downward-sloping demand curve and produce an output that does not exhaust available scale economies, and firms would have the reason just noted to diversify their plants' outputs, to mitigate the disadvantage of small plant scales even at the cost of some scope diseconomies.

Consider a specific cost structure that could underlie this plant-diversity problem. Assume that each activity incurs a constant marginal cost, but scale economies result from fixed costs. Designate the fixed cost of a plant (it may embrace the overhead cost of the firm as well) as F, the fixed cost of producing any particular product as G. If the plant supplies more than one output, it incurs an additional coordination cost Z that is a function of the number and size distribution of the outputs assigned to the plant. Z includes the cost of coordination to mitigate any diseconomies of scope plus the unmitigated cost penalty that remains. If sets of products assigned to the plant give rise to any scope economies, however, Z could be partially or fully

offset.[3] The larger is F, given G, the more products does the profit-maximizing firm assign to the plant, and the higher Z results from the firm's choice of activities. A larger G, given F, deters the production of a particular good in several plants unless G once incurred creates a capability that can costlessly be applied at additional sites (a case that we consider subsequently). Elevation of Z encourages the firm to employ smaller and more specialized plants. While this framework is useful for predicting and evaluating plant-level diversification, it omits some potentially important factors. One of these is how Z might vary with the plant's overall scale. Adam Smith's famous proposition that the division of labour increases with the extent of the market implies that coordination costs are subsumed by the advantages of specialized activities. Adding an activity entails an additional G but also buys a lower variable cost for the combined output, so that any increase in coordination costs may be offset by the advantages of proliferating activities as overall scale increases.

It is useful to consider how plant diversity responds to exogenous changes in market size. We consider subsequently how plant-level diversification relates to the open economy, with its market disturbances and policy interventions. The exact effect of size on the organization of production depends on how firms compete, differentiation of the product, supply of potential entrants, etc. However, under reasonably general conditions (including constant marginal costs), we expect enlargement of the market to induce some combination of increased output per firm and increased numbers of competitors, accompanied by a lowered equilibrium price. Given the assumed structure of costs, this change reduces the firm's incentive to pack diversifying products into a plant in order to spread plant fixed costs. In-plant diversification should on average decline over time as the economy grows, a pattern that Gollop and Monahan (1991) observed for the United States.

A little statistical evidence pertains to this formulation. Caves (1975) found that little of the variance in diversification levels among Canadian manufacturing industries could be explained statistically. However, these diversification levels are significantly correlated with plant-level diversification in counterpart U.S. industries. Furthermore, several statistical relationships that emerged are consistent with the hypothesized trade-off between plant-level diversification and plant size.

2.2 Output diversity at the firm level

The reasons for diversification to occur at the firm level have been studied more extensively (Montgomery, 1994, provided a good survey), so they will be treated briefly here. A natural starting point is the firm-level counterpart of economies of scope at the plant level. In the preceding section, these were implicitly regarded as an artifact of technology. An economic choice is involved, however, and its determinants stand out when we consider how scope economies arise for the firm. In many industries, production requires the services of inputs or assets that share three key properties. First, they are useful or required inputs in producing or distributing several individual products. An example is the distribution system that can efficiently place many individual products on the shelves of grocery markets. Second, they are subject to substantial economies of scale, so that the manufacturer of a single food product tends

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3. This set-up draws on Caves (1975) and a series of papers by Horstmann and Markusen (e.g., Horstmann and Markusen, 1992).

to use its distribution system at an inefficiently small scale, or subject to excess capacity. Third, the asset should be not only "lumpy" and prone to excess capacity but also durable, so that the excess capacity incurs a substantial cumulative cost.

The force of these conditions needs some explanation. Why does the single-product firm employing a lumpy asset not expand in its base market sufficiently to exhaust this economy of scale? The obvious answer echoes the logic of chosen plant sizes: the required scale would be large relative to the market for the firm's core product, so that diminishing marginal revenue (perhaps associated with resistance from oligopolistic rivals) limits this way to exhaust lumpy assets' capacities. Why does the firm deploying such a lumpy asset choose to own it, when it and other users might rent its services from an independent owner who could thereby keep it fully used? The answer is supplied by Williamson's (1985) analysis of the hazards to arm's-length transactions in the services of assets that possess transaction-specific properties—his explanation why vertical integration likely prevails to combine the ownership and use of such assets. Empirical evidence supporting this model of diversification was provided by Lemelin (1982) and MacDonald (1984).

A related analysis of these conditions was offered by Montgomery (1994), who invoked Penrose's (1959) analysis of the growth of the firm. Growth involves the continual acquisition of lumpy assets that leave the firm with a constantly shifting pattern of excess capacities in individual assets that are gradually absorbed by its growth. Diversification might be an efficient way to fill such a capacity at a particular point in time, yet the excess capacity that warranted adding another product might be invisible to the observer who subsequently tries to understand the firm's diversification history.

An important lesson for our empirical analysis from the preceding explanations for the firm's diversification is that we should control for differences in industries' structures that are likely to activate these motives for diversification. Other explanations exist for corporate diversification, but they pertain little to the statistical relationships explored in this study. One such explanation turns on shortcomings of corporate governance that can promote diversification within the firm (e.g., Markides, 1995). Another identifies the possibility that diversified firms meeting each other in several markets will compete less vigorously (Bernheim and Whinston, 1990). The role of multinational firms in diversification will be considered subsequently.

3. Changes in specialization and trade liberalization

The theory of plant diversity that was outlined in the preceding section was keyed to the assumed disturbance of a change in market size, whereas our empirical concern is with trade liberalization as the exogenous agent of change. A summary of the major changes in Canada's trade policy and their principal consequences sets the scene for linking diversity choices to trade restrictions.

Changes in specialization have coincided with major changes in trade intensity associated with trade liberalization. Canadian tariffs steadily declined over the three decades studied here, first with the Kennedy round in the 1970s and then with the Tokyo round in the 1980s. The average nominal tariff (customs duties paid divided by imports) was 6.5 per cent in 1973 and had

declined to 4.0 per cent by 1984 and then to 3.3 per cent by 1989. With these declines came an increase in trade intensity. The ratio of exports to production in the manufacturing sector increased steadily from 25 per cent in 1973 to 31 per cent in 1989. Over the same period, imports as a percent of domestic disappearance (production minus exports plus imports) increased from 26 per cent to 32 per cent.

3.1 Liberalization and expansion of trade

Starting in 1989, two major changes occurred in the trading environment that faced Canadian manufacturers. First, the Canada-United States Free Trade Agreement (FTA) guaranteed a new type of open-border arrangement between these two countries. Then the North American Free Trade Agreement (NAFTA) in 1994 brought together Canada, Mexico and the United States. These agreements continued a process that extended back to the post-World War II commitments to reduce tariffs and expand international trade. The average tariff collected continued its downward trend during the 1990s—from 3.3 per cent in 1989 to 1.1 per cent in 1996. But the FTA and NAFTA changes marked a turning point in that they set a time table for the elimination of tariffs and a framework for the resolution of trade disputes that was intended to give companies greater certainty for foreign direct investment.

The result was an increase during the 1990s in both the export intensity and the import intensity of the Canadian manufacturing sector. Export intensity and import intensity increased from around 31 per cent in 1990 to 47 per cent in 1997. The FTA allowed a process that had begun in the 1970s and 1980s to continue into the 1990s. Manufacturing activity shifted from primarily facing import competition to being more export-oriented; this transition provided the link between trade liberalization and the expected impact of increased market size on diversity. The import-competing segments of Canadian manufacturing may also have responded to trade liberalization as there would be increased competition in an enlarged domestic market.

Previous empirical work suggests that trade liberalization in the early 1990s might have been expected to increase plant specialization. Earlier studies by Baldwin and Gorecki (1983b, 1986) made use of data for the 1970s to study whether the reduction in tariffs that occurred following the Kennedy round was associated with an increase in plant specialization. During this period of gradual tariff reductions, plant specialization increased slightly as did the length of the production run. Increases in the latter, though not the former, were greater in those industries where tariffs declined the most.

3.2 Liberalization, specialization and multinational enterprise: Theory

The exact effect of trade restrictions or liberalization on firms' diversification choices depends on how competition is modeled.

Eastman and Stykolt (1967) employed assumptions that predict a positive relationship between import restrictions and the diversity (and small size) of import-competing producers. These assumptions may have been a good fit to the Canadian manufacturing sector at the time of their research, but they undeniably look very specialized relative to the range of options offered by economic theory.

A standard quantity-setting (Cournot) approach, for instance, gives the opposite answer: restricting imports increases protected producers' outputs and reduces the incentive to diversify plants' outputs. Also, the FTA simultaneously reduces protection and expands exporting opportunities, calling for a theoretical approach that can accommodate some producers exporting while their competitors contend with competing imports—i.e., that is consistent with intra-industry trade.

We therefore propose to consider trade policy and plant diversification in a market with pervasive product differentiation, such that each producer faces a downward-sloping demand curve. Each supplier produces subject to scale economies, and costs curves may be diverse in average-cost level and extent of plant scale economies (scale economies for plants with the industry's output as their principal product). Imports and potential imports are similarly differentiated and supplied by price-setting producers. A Nash equilibrium prevails, each producer (and importer) taking its rivals' prices as given.

The high protection of a Canadian manufacturing industry removed importable varieties from the market, lessening the substitution possibilities that face the typical domestic producer, lowering the elasticity of its individual demand curve, and raising the average domestic price. However, some entry of domestic producers likely was attracted. It is possible, though certainly not necessary, that the typical domestic producer's equilibrium output shrank and the incentive to pack the domestic plant with diversifying outputs intensified. In this case, unilateral tariff reductions should correspondingly reduce plant diversity. The plausibility of a positive relation between import restrictions and plant diversity should not detain us, however, because in the FTA's adoption, import liberalization occurs in the context of multilateral tariff reduction. A small country's producers, if they gain access to external markets in which prices now exceed their marginal costs, are likely to face highly elastic demand curves thanks to large markets for exportables. They then select large plant scales that remove the incentive for plant diversification. Other domestic producers with high costs that deny them access to exporting either shut down or expand their production of the domestic market (if the elasticity of the demand that they face has increased). Either way, their actions contribute to reduction of diversity for the industry's average plant.

Notice that these conditions imply that multilateral reductions in trade restrictions, natural or artificial, cause the expansion of intra-industry trade. Economists have widely noticed its expansion over the last half-century, but little attention has been paid to the conditions theoretically sufficient to trigger a simultaneous expansion of imports and exports of closely similar products. Standard trade theory, of course, predicts that trade liberalization will cause a market's competing imports to rise, or exports to fall, but not both. Empirical evidence supports some aspects of this adjustment process. Caves (1990) found that reduced Canadian protection led to the expected contraction of employment in import-competing industries, but capital expenditures, productivity, and ultimately exports indeed increased.

If foreign subsidiaries and domestic Canadian firms face the same demand and production-cost conditions, it is not obvious that they will make different choices about diversification. However, the standard theory of the multinational enterprise (MNE) does suggest that firms under foreign and domestic control might differ in their quantitative responses to changes in

trade restrictions. A staple proposition holds that the MNE exploits its possession of some intangible asset or capability that favours it with lower costs (or greater demand at a given selling price) than a competitor not so blessed. That process can affect its decisions to diversify.

We continue to depict the firm's costs as either a fixed or constant variable. Assign the firm one central fixed cost F as before in section 2.1, but also a fixed product-development cost E for each good that it produces anywhere in the world. E once incurred creates an intangible asset that can be put to use anywhere in the world. To serve any given national market (Canada), the firm can either export from its home-country plant, incurring a border-crossing cost t per product unit shipped, or establish a local plant. In setting the specifications for the local plant, it faces the choice described previously between a larger and more diversified or smaller and more specialized plant. A new element now enters in the set of products for which the MNE has already incurred cost E and can arbitrage at no further cost to a Canadian plant. A domestic firm could of course have its own portfolio of established products for which E had been incurred, but then it could claim symmetrical status as a MNE. Given the numerical preponderance (in other industrial countries as well as Canada) of domestic-market firms, we expect to find a substantial difference in any given industry between the portfolio of E-paid products of a multinational and that of the average national firm. A disturbance (tariff increase, for example) that makes in-plant diversification more attractive should then elicit a greater infusion of E-paid products from the MNE than its domestic competitor. But the process should also work in reverse. The removal of tariff protection (reduction of t) finds the MNE with the opportunity to transfer the production of secondary products to plants elsewhere in the world. Higher price-cost margins could result by accessing elsewhere lower variable costs for such products or reducing the penalty for scope diseconomies somewhere outside of Canada. In short, we expect a trade-policy incentive for diversification to elicit a larger increase in diversification by the MNE, and similarly the removal of such an incentive.

4. *Nature of the data*

The data used here to investigate changes in plant-level diversification come from a longitudinal data file on all plants in the Canadian manufacturing industry over the period 1973-1997. This longitudinal file is based on data that are derived from both survey and administrative sources that provide plant-level data for the universe of plants in the manufacturing sector. The survey data are derived from long-form questionnaires (generally filled in by the largest plants) that contain the most detailed information, including commodity data, and short-form questionnaires (generally filled in by smaller plants) that are much less detailed. In addition, for the very smallest plants, administrative data on sales and employment come from tax records.

In this database, a plant's sales are classified to one industry.[4] Each plant is identified as being part of a firm and thus firm-level information on the distribution of its sales by industry is available for the measurement of patterns of diversification across industries. Detailed information at the plant level includes the 1980 SIC, employment, value of shipments and value

4. Plant specialization ratios are published to indicate what proportion of the sales of plants in an industry is derived from commodities that are classified to that industry.

added, nationality of control, age of plant, exports, the SIC of the industry to which the plant is classified, and whether the owning firm possess multiple plants.

Since each of the plants in the data base possesses a firm-level identifier, firm diversification indices can be calculated by examining the number of manufacturing industries in which the plants of a firm operate and the distribution of the relative importance of a firm's activity in these industries.[5] In this study, each firm is classified to a principal industry according to its value-added weighted manufacturing activity of all of its plants and its diversification across all industries based on the location of its plants is then calculated.

In addition, annual commodity data for all products produced (both primary and secondary) are available for all plants that received a long-form (detailed) questionnaire. The survey collects data on the value of shipments and quantity of each commodity produced in the plant. We use these commodity data to calculate an index of diversity across commodities for plants and for firms.

It should be noted that sometimes a multi-plant firm does not report commodity data for all its plants. Therefore, firm commodity data may not be completely accurate.[6] In an earlier paper Baldwin, Beckstead, and Caves (2002) examined whether this creates a problem by grouping the plants for which commodity data are available into different categories based on the type of firms to which they belong—whether the firm is diversified across unrelated or related industries. We then compared the results for each category to see if major differences exist in the changing patterns of diversity and found they did not.

5. *Entropy measures of diversification*

In this paper, we use a diversification measure that takes into account both the number of commodities that a firm produces and the distribution of its activity across commodities. The commodity dimension utilizes over 7,000 commodities. An entropy measure of diversification is employed (see Jacquemin and Berry, 1979). We estimate how concentrated a plant's sales are at the commodity level. The entropy index takes the general form:

$$(1) \qquad E(s) = \sum_{i=1}^{N} s_i \log(1/s_i)$$

where s_i equals the share of total firm or plant sales in product i. The entropy diversification index takes a value of zero when sales are concentrated within a single product line. At the other extreme, if the plant's activity is spread evenly across K products, the plant's entropy is maximized at E(s) = log(K). The log entropy measure can be standardized by dividing by log(K).

5. Since the source of data is a manufacturing survey, only manufacturing plants are included. This means that diversification of manufacturing firms outside of the manufacturing industry is not covered here.
6. The survey is designed with the plant, not the firm population in mind.

The entropy measure will be calculated both for the universe of plants and for only those that are multi-product entities.

6. *Plant level commodity diversification*

6.1 Changes over time

In order to investigate commodity diversification at the plant level, we make use of the commodity data from the Annual Survey of Manufactures. Not all plants are asked to enumerate the types of commodities that are produced. In what follows, we report the entropy measure for all plants that enumerated commodity data—what is referred to as the long-form population. A more extensive description of the data can be found in Baldwin, Beckstead and Caves (2002).

We begin with summary statistics on the extent and trend of product diversification for Canadian manufacturing plants. Figure 1 presents mean diversification indexes for foreign-controlled and domestic-controlled plants over the period 1973-1997. There is a downward trend in plant diversification over the period for both types of plants. The decline is faster for foreign-controlled plants, particularly before 1988. In the 1970s, foreign-controlled plants are much more diversified than their domestic-controlled counterparts. In 1996, their difference in diversification was quite small.

This pattern is arguably consistent with the theoretical analysis of the MNE's product-allocation decisions (Section 3.2). At the start of the period, business units in Canada's manufacturing sector had enjoyed a long history of relatively high protection, and foreign trade restrictions (along with underlying comparative-advantage patterns) had confined sales to the domestic market. MNEs responded to these conditions by packing products in their repertory into diversified Canadian plants. They were also, however, well equipped to dismantle this diversification as the policy incentives changed. We do not attribute any particular significance to the remaining difference between domestic and foreign plants. We have not yet controlled for important factors such as plant-size differences or differences in industry mix that could account for a permanent differential. It may be significant though, that before 1988, the decline in diversification in product specialization was more rapid for foreign-controlled plants. However, after 1988, the decline was faster for domestic plants.

The decline in plant diversification in Figure 1 is a result both of a decline in the share of plants that produce more than one product and a decline in the diversification of these multi-product plants, as shown in Figures 2 and 3. In 1973, 73 percent of foreign-controlled plants and 65 percent of domestic-controlled plants produced more than one product. By 1998, the share of multi-product plants was 57 percent for foreign-controlled plants and 50 percent for domestic-controlled plants. That represents about a 15 percentage point drop for both foreign- and domestic-controlled plants. Figure 3 demonstrates that the decline in the product diversification for multi-product foreign-controlled plants is much faster than domestic-controlled plants over the period 1973-97. Output diversification was higher for foreign-controlled plants in 1973. In 1997, output diversification was similar between the two groups.

Figure 1. Product diversification of manufacturing plants

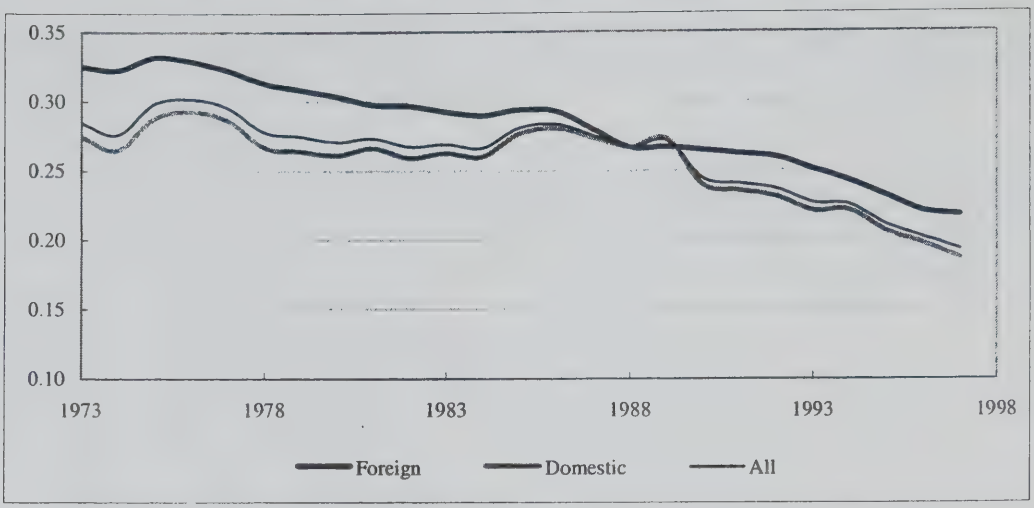

Figure 2. Share of multi-product plants in manufacturing

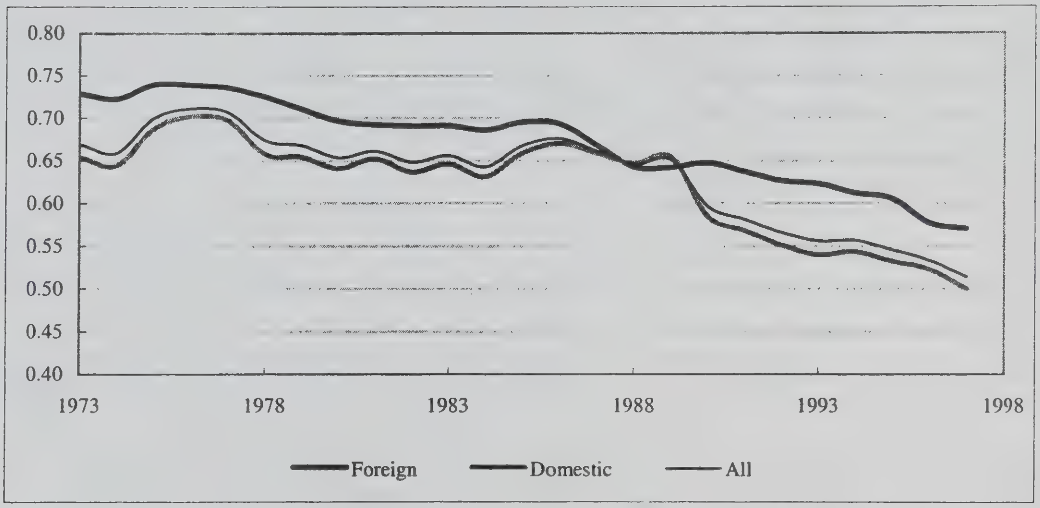

Figure 3. Product diversification of multi-product plants in manufacturing

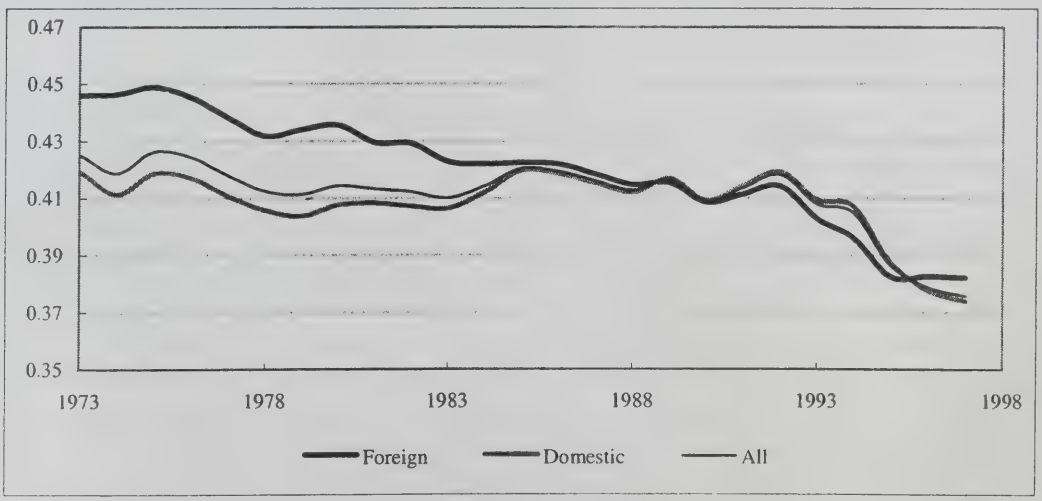

Table 1. Annual changes in product diversification of foreign- versus domestic-controlled plants

	1980-1988	1988-1997	Changes in two periods
All plants			
Changes in product diversification	-0.0005	-0.0081	-0.0076
Contribution from:			
Changes in share of multi-product plants	-0.0004	-0.0058	-0.0054
Changes in product diversification of multi-product plants	-0.0001	-0.0024	-0.0023
Foreign-controlled plants			
Changes in product diversification	-0.0046	-0.0054	-0.0008
Contribution from:			
Changes in share of multi-product plants	-0.0029	-0.0032	-0.0003
Changes in product diversification of multi-product plants	-0.0017	-0.0022	-0.0005
Domestic-controlled plants			
Changes in product diversification	0.0007	-0.0088	-0.0095
Contribution from:			
Changes in share of multi-product plants	0.0003	-0.0064	-0.0067
Changes in product diversification of multi-product plants	0.0004	-0.0024	-0.0028

We naturally inspect these figures for evidence of two major changes that occurred for the Canadian manufacturing sector. First, the Free Trade Agreement (FTA) between Canada and the United States, which took effect January 1, 1989, led to the gradual removal of tariff barriers between the two countries. Then the North American Free Trade Agreement in 1994 brought together Canada, Mexico and the United States. Our data on plant specialization shows a clear break around the time that the FTA was adopted. As shown in Table 1, product specialization in Canadian manufacturing plants advanced much faster after 1988. During the FTA period, both the amount of decline in the share of multi-product plants and in the diversification of multi-product plants have increased. This is consistent with the view that trade liberalization drove the increased plant specialization in the 1990s.

6.2 Analysis of changes in plant specialization

While the relationship that we have described in the previous section between relatively aggregate measures of the changes in commodity specialization and trade barriers suggests that the two were linked, corroborative evidence is required that links changes in trade barriers at the plant level to changes in specialization that were occurring.

We do so first by using cross-sectional data to examine the extent to which plant diversity varies with industry characteristics and the level of the tariff. In this section, we test the basic hypotheses outlined in the previous sections on the nature of industry characteristics that lead to diversity, with particular attention being paid to the effect of tariffs on diversity and whether foreign-controlled plants differ from domestic plants after conditioning on their industry and plant characteristics. We then turn to panel data to test whether changes over time in tariffs and other plant characteristics have led to behavioral changes that our theory has suggested.

6.2.1 *Cross-sectional determinants of plant diversification*

In this section, we ask two questions. First, what are the characteristics of industries that are linked with plant diversification? Second, what are the characteristics of plants that are related to plant diversification?

The first question focuses on the demand and supply conditions at the industry level that determine the 'average' forces behind the level of diversity chosen. The second question allows us to examine heterogeneous behaviour within industries. Plants and firms within industries differ substantially—both with regards to the demand conditions faced and the technologies utilized. Foreign-controlled plants, for example, have been hypothesized to have different supply conditions (the possession of assets) that generate lower fixed costs per product that would engender more diversity but at the same time also provide more possibilities for interplant allocation of production.

To answer these questions, we use a cross section of plants and regress the plant diversification index (PD_p) on a set of industry characteristics (X_i) and a set of plant characteristics (Z_p):

$$(2)\ PD_p = \alpha + \beta X_i + \chi Z_p + \varepsilon_p$$

For this exercise, we construct a data set on plants in the manufacturing sector for the years 1980 to 1997. Data on manufacturing output (shipments), and employment are available throughout the period from the Census of Manufactures for each plant in the manufacturing sector. From this data set, measures of individual plant product diversity are calculated, as well as other plant characteristics. To these data are added characteristics of the plant's owning enterprise—whether the firm is foreign-owned, small or large, young or old, or part of a multi-plant enterprise. In addition, the percentage of sales that are exported is added. While the latter is only available for plants that answer the long-form questionnaire, this is the same group for whom we have commodity data and for whom we calculate a commodity entropy measure—our product specialization ratio.[7]

The industry characteristics X_i include Canadian and U.S. tariff rates, and binary variables to account for industry differences in the factors attracting diversification. The plant characteristics Z_p include plant ownership, plant size, age of plant, export participation, and multi-plant status of the firm to which the plant belongs.

Canadian and U.S. tariff rates – Tariff rates cover the period 1980-1996.[8] The Canadian tariff rates are based on duties paid that are collected by commodity. These commodities are assigned to industries based on the primary industry of production. Average tariffs are then calculated using import values as weights. U.S tariff rates are once again based on import duties by

7. Long-form plants accounted for 66% of the population in 1974 but only 49% in 1993. However, they accounted for 95% and 87% of shipments in these two years.
8. These tariff rates were kindly supplied by Professor Trefler. The Canadian tariff rates were calculated by the International Trade Division of Statistics Canada to his specifications. Trefler calculates the U.S. tariff rates using data from Feenstra (1996).

commodity, are assigned to an industry using the same Canadian concordance table used for Canadian commodity duties, and then aggregated based on U.S. import weights.

Canadian tariff rates against imports from the United States and the U.S. tariff rates against Canadian imports are expected to be positively related to plant diversification.

Diversity potential – Our hypotheses about diversification and trade restrictions address market mechanisms and changes in public policy that can trigger them. To isolate these, we need to control the technical synergies that affect plant-level diversification. Not only should these contribute to explaining diversification and its changes, but as we also suggested in section 2.2, motives for firms to diversify surely affect their plants' diversity of output. The reasons for firm-level diversification are numerous, and many vary in their force from industry to industry. We thus need to control for inter-industry differences in bed-rock features of technology and demand.

As argued, the existence of lumpy fixed assets that have not been fully exploited should be associated with greater levels of diversity. A number of different industry characteristics are hypothesized to signal the existence of these types of assets. They provide an avenue for identifying observable characteristics of industries that should affect their potential for efficient diversification.

First, industries that enjoy substantial scale economies are hypothesized to have more incentive to add product lines to a plant to exploit these economies. Second, advertising intensity, which is associated with the presence of value reputation associated with brands, should lead to higher levels of diversity. Differentiation embraces both intrinsic physical heterogeneity and complexity in the product and subjective or style-based differentiation. The former is conducive to heavy international trade and large responses to trade liberalization—the familiar intra-industry trade model. The latter is more prone to national taste differences, so that processed food products (for example) tend to enter rather little into international trade.

Industries that stress new product and process innovations also possess the indivisible type of assets that enhance the incentive to diversify—since these assets can be applied to related products in various ways. A patent on one production process may cheapen investments in other product lines that have related production processes. Industries that are R&D intensive are therefore likely to possess the types of assets that lead to diversification.[9]

To capture essential industry characteristics, we have two alternative strategies available to us. In the first case, we can devise single measures that are proxies for the characteristics outlined above. For example, we could proxy the existence of scale economies with a variable that measures concentration. Or style differentiation seems to be well identified by industry-level advertising/sales ratios. To capture the science-base of an industry, the ratio of R&D expenditures to industry sales could be used. Another characteristic that serves as a general proxy for the activities that generate intangible assets of various sorts is the number of non-production employees as a percentage of total employees. Non-production workers include research scientists, salesman, and managers. Research workers may discover new product lines

9. A finding that is substantiated by the classic work of Gort (1962).

or new processes that can produce new product lines. Salesmen may be able to promote additional products at low marginal costs. Plants in industries with high overhead costs are expected to have more incentive for producing multiple outputs.

As an alternative to using each of the above single characteristics, we adopt a different strategy and draw upon a simple classification of industries that in past research has proved strikingly successful at supplying a control that captures the type of industry classification that is needed here. We aggregate manufacturing industries defined in the standard industrial classification into just five categories—five groupings that capture in a broader way the nature of differences in the existence of complementary assets that lead to diversification. The differences that we have described may not be captured adequately by the set of variables like R&D or advertising. The industry groupings used here are natural resources, labour intensive, scale-based, product differentiated and science-based industries.[10] These groupings were constructed via discriminant analysis using a large number of industry characteristics—such as R&D, advertising, estimates of economies of scale, wage rates, the ratio of value added to total sales, ratios of non-production employment to total employment.

Science-based industries are those where R&D and non-production workers are more important than elsewhere. These industries develop knowledge-based assets that are conducive to diversification. Scale-based industries are those with high capital intensity and where scale economies are more important and where suboptimal scale is costly. Labour intensive industries are those with lower wage rates and higher labour/capital ratios than elsewhere. Product differentiated industries possess assets associated with brands. The natural resource sector contains industries where raw material inputs are relatively important, but also include the food processing sector where product differentiation is high.

Nationality of plant ownership – To examine differences between plants that are foreign- and domestically-controlled, we use a binary variable that takes on a value of 1 if the plant is owned by a firm that is controlled from abroad and zero otherwise. The definition that is employed here is basically that used in the Corporate and Labour Returns program—that is, at least 50 per cent of voting equity is controlled by foreign residents.[11]

Foreign subsidiaries should be less attracted to 'excess' diversification than domestic enterprises, because they generally have options for adjusting to small markets that are not open (or open only with contractual hazards) to their domestic competitors. For example, items in a product line or inputs subject to scale economies can be sourced abroad from a corporate sibling rather than produced at high cost domestically. However, multinational status should also increase the firm's propensity to undertake local production in response to trade restrictions (section 3.2). Thus, foreign control might well increase a plant's move toward specialization in response to tariff reductions: the relative level of diversity in foreign-controlled plants thus should depend on the prevailing degree of trade restriction.

10. For a discussion of the definitions of these sectors, see Baldwin and Rafiquzzaman (1995).
11. Exceptions are made when it is known that control is obtained with less than a 50% voting share.

Export participation – The concept of excess plant diversification is associated with the notion that domestic markets are constrained in size and that the response of producers to this constraint involves a trade-off between scale of product line and scale of plant. Plants that export should not face the same tradeoffs because they already compete in the larger American market. Therefore, we add a binary variable to denote whether the plant is an exporter. While these variables are only available for plants that answer the long-form questionnaire, this is the same group for whom we have commodity data and for whom we calculate a commodity entropy measure—our product specialization ratio.[12] A large number of previous studies find that exporters are more productive and more innovative than non-exporters (Baldwin and Gu, 2003; Bernard and Jensen, 1999). However, there is little evidence on the link between export participation and plant diversification. One exception is the paper by Baldwin, Beckstead and Caves (2002), which found that more export-intensive plants are more specialized, producing fewer products.

Plant size – If economies of large-scale plant operation encourage diversification, a positive relation between the scale of a plant's production in the Canadian market and its output diversity should be expected. Some firms will find an effective diversification strategy that supports larger scale and lower costs, while others will choose to operate at a smaller scale with more specialization.

A limitation of our analysis is that the selection of a plant's scale is theoretically interdependent with the choice of its product mix. We put this problem aside, because endogenizing plant size is a difficult problem to address, and our concern is not with obtaining an unbiased coefficient but confirming the relatedness of two variables.

We measure scale here as the logarithm of total employment in the plant. Gort (1962) and Baldwin, Beckstead and Caves (2002) found that large firms are more diversified than small firms.

Age of plant – We have constructed a binary variable for each plant which takes a value of one if the plant is less than five years old and zero if more than five years old in the year used for the multivariate analysis. There are two reasons to suspect that young plants will be more specialized.

The first relies on the notion that optimal diversification may have changed over time—with specialization becoming greater. In this case, young plants are hypothesized to be more likely than older plants to choose a product mix that is optimal under current conditions. If reductions in tariff barriers and increases in market size over time are related to higher plant specialization, young plants will be more specialized than older plants.

The second relies on the belief that heterogeneity found in firm and plant populations is partially the result of the stage of the learning process at which each producer finds itself. Young plants are less likely to have learned how to combine products in order to exploit scope economies, just as they are less likely to have learned how to develop more capital intensive technologies, or to collaborate with other firms to produce innovations.

12. Long-form plants accounted for 66% of the population in 1974 but only 49% in 1993. However, they accounted for 95% and 87% of shipments in these two years.

Multi-plant status – A firm's complexity, particularly the extent to which it is operating plants across different regions and industries is expected to affect the extent of product specialization, though the sign is ambiguous. A multi-plant firm is one that has already decided that scale economies are close to being exploited or it would not have moved to producing out of separate plants (Lyons, 1980). In this case, these plants have less incentive to diversify in order to exploit economies of scale. Additionally, a multiproduct firm has the possibility of producing a given product in another plant (specialized or not) rather than the plant at hand. On the other hand, it must be recognized that multi-plant status is connected to cross-industry diversification and difficult empirically to separate from it. And firms that are cross-industry diversified are more likely to possess the types of assets that lead to greater product diversification at the firm level—and therefore to simply produce more products per plant, even if there are scope diseconomies at the plant level. In this case, we would expect a positive coefficient on multi-plant status. Therefore the sign that is hypothesized for the coefficient associated with this variable is uncertain. This variable is captured with a dummy variable that takes on a value of 1 if the plant belongs to a multi-plant firm. We expect a negative sign.[13]

The regression results from a cross-section of some 18,000 plants are presented in Table 2. Variable descriptions are included in Appendix A. A tobit regression is used because of the large number of plants that produce only a single product.[14,15] OLS estimates that fail to account for this left-censoring in the sample are downward biased.

In Table 2, the first column contains the hypothesized signs. The second column contains the parameters for all the control variables without tariffs. The third column includes both tariffs and industry characteristics associated with the incentive to diversify. The fourth column is the complete set of industry, plant, and tariff variables. Columns 5 and 6 reproduce the results for the complete set of variables used in column 4, but split the sample into foreign and domestic plants respectively.

Higher Canadian and U.S. tariff rates are both linked to greater plant diversification. This is consistent with the view that plants in industries that are protected by trade barriers tend to be more diversified, producing too many products with limited scales. Interestingly, U.S. tariff rates have a greater impact on product diversification levels than do domestic tariffs. It is the tariff rates in the larger country that dominate the diversification decision of plants in the smaller country. When the sample is broken down into foreign and domestic plants (columns 5 and 6), the diversification levels of both foreign and domestic plants are affected relatively more by U.S. tariffs—though the ratio of the effect of U.S. to Canadian tariffs is greater for domestic plants (5:1 versus 2:1). This is consistent with the normal argument that foreign plants react to the Canadian tariff by establishing plants here that benefit by diversification—and that domestic Canadian plants face barriers in export markets that they partially offset by diversification.

13. We also experimented with a measure of the industry diversity of the owning firm, which is closely related to whether a firm is multi-plant. Our results were qualitatively the same whether we use the diversity or the multi-plant measure. We would like to be able to distinguish those firms that are horizontally as opposed to vertically diversified but cannot do so in this database.

14. Because we combine both plant and industry characteristics, we tested whether there was autocorrelation across industries and found none.

15. Some small plants that are excluded from the ASM sample—but they most likely produce single products.

Table 2. Product diversification by industrial sectors in 1990, Tobit estimates

	(1) Expected sign	(2) All plants	(3) All plants	(4) All plants	(5) Foreign plants	(6) Domestic plants
Industry characteristics						
Canadian tariff	+		0.580*	0.461*	0.728*	0.340*
			(6.60)	(5.43)	(3.95)	(3.55)
U.S. tariff	+		1.690*	1.663*	1.369*	1.790*
			(11.77)	(12.06)	(3.77)	(11.79)
Labour intensive sector			--	--		
Natural resources sector	+	0.015	0.148*	0.134*	0.082*	0.145*
		(1.85)	(14.69)	(13.73)	(3.45)	(13.59)
Scale-based sector	+	-0.007	0.176*	0.132*	0.093*	0.141*
		(-0.81)	(15.56)	(12.05)	(3.62)	(11.66)
Product-differentiated sector	+	-0.111*	0.027**	0.014	0.075*	-0.007
		(-10.04)	(2.14)	(1.14)	(2.79)	(-0.47)
Science-based sector	+	-0.056*	0.097*	0.067	0.130*	0.018
		(4.12)	(6.49)	(4.63) *	(4.810	(0.99)
Plant characteristics						
Foreign-controlled plants	?	-0.019**		-0.014		
		(-2.18)		(-1.62)		
Plant size	+	0.089*		0.084*	0.079*	0.086*
		(34.51)		(32.99)	(14.92)	(29.33)
Young plants	-	-0.077*		-0.081*	-0.134*	-0.075*
		(-8.37)		(-10.82)	(-6.31)	(-9.30)
Exporters	-	-0.055*		-0.051*	-0.019	-0.055*
		(-4.96)		(-7.82)	(-1.26)	(-7.64)
Multi-plant firm	-	-0.038*		-0.025*	0.068*	-0.043*
		(-4.96)		(-3.33)	(3.93)	(-5.08)
Constant		-0.090*	-0.050*	-0.247*	-0.319*	-0.246*
		(-8.53)	(-4.77)	(-19.13)	(-9.05)	(-17.27)
Number of observations		18,374	18,372	18,372	3,418	14,954
Likelihood ratio		-10,881	-11,475	-10,637	-1,890	-8,691

Note: t statistics are in parentheses and are heteroskedastic-consistent. * represents a level of significance of better than 1%; ** 5 percent and *** 10 percent.

Despite this difference, the important point is that both groups are affected to some extent by both sets of tariffs.

Substantial differences exist across industries in plant diversification (Table 2, column 3). The rank order of these sectors arguably matches one's sense of the prevalence of synergistic opportunities, with scale-based industries plausibly more diversified than labour-intensive industries. The high incidence of diversification in scale-based industries matches our model of plant-level diversity as a way to mitigate diseconomies of small plant scale. The position of natural resources may seem surprising, but note that it includes food processing, a subsector with substantial product differentiation.

If specific industry characteristics are included rather than the five-sectoral variables included here, the industry characteristics generally have the hypothesized signs (results not reported here). There are positive and significant coefficients on advertising/ratios and the share of non-production workers, thereby suggesting that plants in industries with large overhead costs are more diversified.

We add plant characteristics to the industry classifications in column 4 of Table 2. Once this is done, the coefficients attached to the industry variables retain their significance—though they decline slightly, not unnaturally because some plant variables (size, foreign ownership) are also related to them.

The coefficient estimates on plant characteristics indicate that: (1) foreign-controlled plants are more specialized that domestic-controlled plants; (2) large plants are more diversified than small plants; (3) young plants are more specialized than older plants; (4) exporters are more specialized that non-exporters; (5) the output diversification of a plant is negatively related to the multi-plant status of its parent firm.

Our findings on plant size and export participation are consistent with the evidence from previous studies (Baldwin, Beckstead and Caves, 2002; Gort, 1962). Large plants differ from small plants in that they are more diversified. The finding that exporters are more specialized confirms that plants serving export markets are less likely to face the constraints of small markets that lead to plant diversification. Moreover, the export status is more likely to affect domestic plants, which once more suggests that border effects are less severe for multinationals who are better able to arrange their portfolio of products across plants on both sides of the border.

The finding that foreign-controlled plants are more specialized after considering other plant characteristics indicates that this group benefits from being able to optimize the production of products across national boundaries.

Large plants are more diversified and younger plants are more specialized. These results emphasize that the population of plants is a dynamic one. On average, plants start at a smaller scale than the average size. And these are relatively specialized. Over time, the more successful firms grow their plants. To do so, they have to make difficult transitions. Most have to learn how to increase their capital intensity. But they also grow by learning how to combine products in the production process—to exploit both scope and scale economies.

Finally, plants of multi-plant firms are more likely to be specialized, thereby confirming the hypothesis that these plants have already exhausted scale economies and are less prone to diversification. But it should be noted that the sign of this coefficient differs for foreign as opposed to domestic plants. It is negative for domestic plants—but it is positive for foreign plants. This is consistent with the argument that foreign firms possess more of the intangible assets that lead to higher levels of firm diversification (for reasons of firm scope economies in distribution or R&D). Firms with more diversification will add products at the plant level even when scale economies are exhausted.

6.2.2 *Trade liberalization and changes in product diversification*

Prior to the Canada-U.S. Free Trade agreement, it was argued that a reduction in trade barriers would reduce product diversification at the plant level and improve the length of production runs. Operating behind tariff barriers and with limited market size, Canadian plants were seen to have production runs that were too short to exploit economies of large-scale production. However, there is little existing evidence on the link between tariff reductions and increases in plant specialization, though Baldwin, Beckstead and Caves (2002) report that plants that become more export-intensive had larger declines in product diversification. As rising export intensity is related to tariff reductions in the Canadian manufacturing sector, this evidence is consistent with the view that trade liberalization is related to increased plant specialization.

In this paper, we take a different approach and directly examine the relationship between changes in tariff rates and increases in product specialization. We use a panel regression that relates changes in plant diversification to tariff reductions in the industry to which the plant belongs:

$$(3) \qquad \Delta PD_{pt} = \alpha_t + \beta_1 \Delta \tau_i^{CAN} + \beta_2 \Delta \tau_i^{US} + \gamma_1 X_{pt} + \gamma_2 Z_{it} + \varepsilon_{pt}$$

where ΔPD_{pt} is the average annual change in the product diversification of plant p during a period t; $\Delta \tau_{it}^{CAN}$ is the average annual reduction in Canadian tariff rates against the U.S. imports; $\Delta \tau_{it}^{US}$ is the average annual reduction in the U.S. tariff rates against Canadian imports (where, for expository purposes, a tariff reduction is treated as a positive number); X_{pt} is set of plant characteristics *at the start of a period* that includes initial diversification levels, plant ownership, the log of plant employment, age of plant, and multi-plant status of the owning firm. Z_{it} is set of industry characteristics that are proxied by the industry sector variables that were used in the last section.

We ask whether plants in industries with larger tariff cuts had larger declines in plant diversification. As we have defined tariff changes as $\Delta \tau$ over a period, a negative coefficient on the tariff cut variable indicates that the plants in the industries with large tariff cuts have a bigger decline in product diversification.

Our strategy, in the first instance, is to ask whether changes in the variable of interest (tariffs) is related to changes in specialization, all the while conditioning on the values of plant and industry characteristics with which plants and industries began the period. Changes in tariffs are included to investigate the key issue addressed herein—whether trade liberalization, as represented by tariff cuts, was associated with improvements in product specialization.

The industry characteristics are included to capture whether reductions in diversity are related to the underlying demand and supply conditions that led, in the first instance, to higher *levels* of diversification.

The plant characteristics are included to provide us with evidence on the changes that were taking place within industries in terms of specialization. They allow us to determine whether improvements in specialization took place in specific subsets of the population and thereby to infer what the basic underlying forces behind changes might have been. For example, the diversification of the plant relative to the diversification of the industry in which the plant is located is included to test whether the plants where coordination costs were highest because of existing levels of diversification were those that took greatest advantage of the new opportunities opened up by expanding markets to increase their degree of specialization.

We also recognize that dynamic processes other than changes in tariff rates would have been at work that should be related to changes in specialization. In particular, the normal growth process should be associated with increases in diversity; since this is one of the routes used to enable firms to exploit scale economies. Therefore, we include changes in plant size in the regression, all the while recognizing that this introduces a variable that is likely to be simultaneously determined with changing diversity. Moreover, previous efforts have discovered that modeling growth (finding a strong instrument) is difficult (Baldwin, Sabourin and Smith, 2004). However, omitting plant growth offers the equally daunting consequence of specification bias. Our compromise is to provide the reader with two alternatives—one without this variable and one with it included.

To estimate Equation (3), we composed a panel of plant-level changes over the 1980-1988 and 1988-1996 periods. The sample of plants available for estimation consists of those that produce more than one product at the start of each period. For single-product plants, changes in diversification are necessarily left-censored.[16]

The results from regression (3) are contained in Table 3. In Table 3, the first column contains the hypothesized signs. The second column contains the parameters for the control variables without tariffs. The third column includes both tariffs and plant characteristics. The fourth column is the complete set of plant, industry and tariff variables. Columns 5 and 6 reproduce the results for the complete set of variables used in column 4, but split the sample into foreign and domestic plants respectively.

When introduced separately, we found that the Canadian and U.S. tariff cuts both lead to increased specialization. The coefficients on Canadian tariff cuts were large and statistically significant at the 1 per cent level, suggesting that a one percentage-point annual decline in Canadian tariff rates is associated with a 0.002 annual decline in plant diversification. This represents a 5 percent decline in plant diversification per year for an average plant in our sample. However, with the inclusion of both tariff variables, the American tariff rate reduction became insignificant. The political economy that governed tariff reductions has produced similar cross-industry reductions in the two countries that make it difficult to separate out the effect of each set of tariff reductions. Therefore, in Table 3, we combined the two by taking the simple summation of both. Reductions in this tariff rate variable are accompanied by large significant increases in Canadian plant specialization.

16. We have also run a censored regression using a sample of plants that includes both single- and multi-product plants, the results are similar.

Table 3. Difference in effects of tariff reductions on changes in product diversification between industrial sectors, 1980-1996

	(1) Hypothesized sign	(2) All plants	(3) All plants	(4) All plants	(5) Foreign plants	(6) Domestic plants
Tariff cuts	-		-0.128*	-0.122*	-0.150**	-0.116*
			(-3.94)	(-3.74)	(-2.16)	(-3.14)
Relative plant diversification	-	-0.012*	-0.012*	-0.012*	-0.010*	-0.013*
		(28.881)	(-28.94)	(-28.89)	(-14.90)	(-25.50)
Foreign-controlled plants	-	-0.002*	-0.002*	-0.002*		
		(-3.92)	(-4.06)	(-3.86)		
Plant size		0.001*	0.001*	0.001*	0.001*	0.001*
		(5.50)	(2.55)	(5.52)	(3.50)	(4.15)
Young plants	?	0.0003	0.0009	0.0002	-0.0004	0.0004
		(0.29)	(0.98)	(0.25)	(-0.20)	(0.41)
Multi-plant firm	?	0.0001	-0.0006	0.0001	0.002**	-0.001
		(0.29)	(-0.99)	(0.11)	(1.99)	(-0.81)
Plant growth	+	0.046*	--	0.046*	0.068*	0.039*
		(11.65)		(11.59)	(8.98)	(8.25)
Labour intensive sector			--	--		
Natural resources sector	?	0.002*	0.001	0.001	0.002	0.001
		(2.74)	(1.49)	(1.31)	(1.12)	(0.94)
Scale-based sector	?	0.0006	-0.0001	-0.0005	-0.002	0.000
		(0.77)	(-0.12)	(-0.60)	(-1.37)	(0.34)
Product-differentiated sector	?	-0.005*	-0.005*	-0.005*	-0.004*	-0.006*
		(-4.54)	(-4.87)	(-5.23)	(-2.55)	(-4.33)
Science-based sector	?	-0.003*	-0.004*	-0.004*	-0.003	-0.006*
		(-2.68)	(-2.73)	(-3.11)	(-1.32)	(-3.20)
Fixed effect for period 1988-1996	?	-0.003*	-0.002*	-0.002*	0.0001	-0.002*
		(-4.84)	(-3.60)	(-2.93)	(0.06)	(-3.51)
Constant		-0.015*	-0.010*	-0.014*	-0.018*	-0.013*
		(-11.67)	(-7.69)	(-10.49)	(-6.83)	(-8.23)
Number of observations		10,769	10,769	10,769	3,619	7,602
R squared		0.12	0.11	0.12	0.13	0.12

Note: t statistics are in parentheses and are heteroskedastic-consistent. * represents a level of significance of better than 1%; ** 5 percent, and *** 10 percent.

A number of findings emerge on the link between plant characteristics and changes in product diversification. First, plants that were growing became more diversified. Plant growth and the addition of product lines are closely connected. Diversification is part of the dynamics of the growth process. While the coefficient on this variable suffers from potential simultaneity bias, entering this variable (Table 3, column 2) or omitting it (Table 3, column 1), has no significant impact on the other coefficients in the equation.

Second, the decline in product diversification was faster for foreign-controlled plants than for domestic-controlled plants. Moreover, when the results are run separately for foreign-controlled as opposed to domestic plants, the tariff effect is greater for foreign plants. This confirms that these plants were better able to adapt to changes in trade liberalization during the specialization process.

Third, plants that were relatively more diversified[17] are those where plant diversification declined the most. Plants that were relatively more diversified would have had the highest product coordination costs and therefore should have been expected to have increased specialization the most as market size increased.

Fourth, specialization increased at faster rates for large plants than for small plants. It is noteworthy that if we do not include the initial level of plant diversification in our regression, the coefficient on plant size is negative. Large plants alone have a bigger decline in diversity than small plants; but this is due to the fact that large plants are more diversified. Once we control for initial diversification, plant size has a positive coefficient.

This suggests that plant-level or scope economies have become more important for larger plants over the period, relative to the cost penalties associated with diversity. Even though the coefficient on plant size is positive in the cross-section regression, it is not obvious that it should also be positive for changes in diversification. For this to happen, the attraction of scale must have changed across size classes—that is, the advantages of incremental improvements in size must have increased for larger plants. This suggests a shift in the nature of technologies or capital intensity between small and large plants in favour of large plants that led to increased opportunities to exploit scale economies via diversification in the 1990s.

In related work, we have found evidence of this occurring. Baldwin, Rama and Sabourin (1999) report the gap in advanced technology use between small and large plants increased in the 1990s. Baldwin and Dhaliwal (2001) report that output per worker in larger plants has increased relative to smaller plants throughout the period. Baldwin, Jarmine and Tang (2004) report the same phenomenon can be found in both Canada and the United States. These studies suggest that the degree of scope economies that provide the incentive to increase diversification probably increased in large plants at the same time as trade liberalization was occurring.

Fifth, the plants that belong to firms with multi-plant operations showed no bigger decline in product diversification. This is consistent with the explanation that the multi-plant variable is essentially capturing situations where plant scale economies are already exploited. But it should be noted that the sign on this variable in the sample of foreign plants is positive and significant. After conditioning on plant and industry characteristics, foreign multi-plant firms were actually increasing diversification over this period. An explanation of this, like that associated with the plant scale variable referred to above, is that the value of the assets of multinational firms that lead to diversification was enhanced by the Free Trade Agreement and that they reacted by actually increasing diversity at the firm level—and this effect was reflected in increased plant diversity.

Sixth, increases in product specialization were greatest in the product differentiated and in the science-based sector. It was here then that there is the most evidence that the type of agglomeration economies that led to product packing at the plant level were mitigated by tariff policies.

17. The relative diversification of a plant is calculated as the percentage difference in the diversification of the plant and the mean plant diversification of the 4-digit SIC industry to which the plant belongs.

Seventh, the negative coefficient on the dummy for the period 1988-1996 indicates that the decline in product diversification is more rapid in the period after the FTA. This acceleration in the trend toward product specialization is not explained by deeper tariff cuts in the period. A possible explanation for the negative coefficient on the dummy for the 1988-96 period comes to mind; when the government lowers a particular tariff, businesses keep in mind the possibility that some future political-economy disturbance might boost it back up again. A treaty-based reduction, however, commits the reduction and reduces or eliminates this incentive to hedge commercial bets, so a given post-FTA reduction could have more effect than the same reduction pre-FTA.

To examine whether the impact of tariff reductions on the change in plant diversification depends on the initial level of diversification at the plant, we also experimented with the interaction of tariff cuts and relative plant diversification (results not reported here). The coefficient on the interaction of tariff cuts and relative plant diversification is negative, which indicates that tariff reductions had a bigger impact on more diversified plants. For a plant with the mean level of plant diversification, a one-percentage point tariff cut is associated with a 0.14 decline in the plant diversification index. A 10-percent increase in plant diversification is associated with a 9-percent increase in the impact of tariff cuts on the decline in plant diversification.

7. Conclusion

Events like the introduction of the Canada-United States Free Trade Agreement (FTA) provide opportunities to test long-standing hypotheses that are at the core of the economic profession's policy kit. In particular, it allows for studies regarding the industrial benefits that a small country joining a regional trade agreement might be expected to gain from the exploitation of scale economies. This paper studies one change that has been predicted to accompany trade liberalization—the increased specialization of plants.

It does so by examining the Canadian experience in a period during which trade was liberalized with the United States and, in particular, the Canadian experience following the adoption of the Canada-U.S. Free Trade Agreement in the early 1990s. It finds that commodity specialization increased over both the 1980s and 1990s; but the pace of commodity specialization increased around the time of the implementation of the Free Trade Agreement between Canada and the United States. This was one of the fundamental outcomes that policy analysts had predicted would occur as a result of the relaxation of trade barriers between the two countries. Canadian industrial structure was seen to be deficient both in terms of plant size and product-run length. While little has been found in the way of adaptation in the way of plant size (Head and Ries, 1999), our work shows that plant specialization changed dramatically after the implementation of the FTA.

The paper has also shed light on the phenomenon of plant diversity that is poorly understood in the industrial organization literature because of a lack of studies in this area. Plant diversity was found to be higher in larger plants based in industries with assets that are associated with scope economies, thereby confirming the related-asset theory of diversification. But diversity is also

higher in industries with higher rates of tariff protection, thereby suggesting that both demand and supply conditions determine the level of diversity at the plant level. This finding helps to define another source behind the negative impact of tariff protection on industrial efficiency.

Over the 1980s and 1990s, plant diversity was shown to have decreased most where tariffs fell most. And the decline was greater during the post-FTA era than before, thereby suggesting that this treaty had an impact above and beyond just the tariff reductions that were associated with it.

The study also sheds new light on differences between foreign-controlled and domestic-controlled plants—an area in which Safarian (1966) pioneered the careful study of the characteristics and behaviour of this group. Our study found the average foreign-controlled plant was more diversified than the average domestic-controlled plant. But these differences were primarily related to the larger size of foreign-controlled plants and the nature of the industries to which they were attracted. After accounting for their larger size and industry of location, they were no more diverse than domestic plants in 1990. More importantly, the study shows that foreign-controlled plants tended to adjust more after NAFTA was implemented. The implication then of this study is that we can look to this group adapting relatively quickly to changes in commercial policy.

The results of this study need extending in one very obvious direction. This paper has only focused on one part of the trade-industrial structure puzzle. A related paper finds a positive impact on productivity of new export activity that took place during the 1990s (Baldwin and Gu, 2003). The work reported here suggests one of the sources thereof. Tracing changes in tariff rates through to changes in industrial structure and trade patterns and the ultimate impact on productivity growth is required if we are to obtain a more complete picture of the complex interaction between trade liberalization, industrial structure and productivity growth.

Appendix A: Variable description and sources

The data for this paper come from a special database that was created for this research project. Most of the data come from a Longitudinal Research File (LRF) derived from the Census (Survey) of Manufactures—a file that was created and is maintained by the Micro-economic Analysis Division of Statistics Canada. The plant characteristics and the industry characteristics variables that are used for this exercise provide us with a time series from 1980-1996.

Age of plant – A binary variable for each plant which, for a particular year, takes a value of one if the plant is less than five years old in that year and zero if it is more than five years old. Age is defined as number of years since the plant first enters the file. The source is the LRF.

Exporter – Derived as a binary variable if the plant lists exports, zero otherwise. The source is the LRF.

Foreign control – A binary variable for each plant that takes a value of one if the plant is foreign-controlled and zero if it is not. The data come from the Corporate and Labour Returns program collected by Statistics Canada. The definition that is employed here is basically that used in the Corporate and Labour Returns program—that is, at least 50 per cent of voting equity is controlled by foreign residents. Exceptions are made when it is known that control is obtained with less than a 50% voting share. The variable exists for the years 1980-1996. The source is the LRF.

Multi-plant – Derived as a binary variable with a value of one if the plant belongs to a firm with more than one plant and zero otherwise. The source is the LRF.

Plant size – The logarithm of total employment of a plant. The source is the LRF.

Product diversity – An entropy measure of the plant's product diversification. See Baldwin, Beckstead and Caves (2002). The entropy variable is created using commodity data at the plant level from the Census (Annual Survey) of Manufactures for the period 1980-1996.

Sectoral variables – Labour-intensive, Natural-resource, Scale-based, Product-differentiated, Science-based sectors. These groupings were constructed via discriminant analysis using a large number of industry characteristics—such as R&D, advertising, estimates of economies of scale, wage rates, the ratio of value added to total sales, ratios of non-production employment to total employment. For a discussion of the definitions of these sectors and the variable used in the discriminant analysis, see Baldwin and Rafiquzzaman (1995).

Tariff rates – Tariff rates cover the period 1980-1996. The Canadian tariff rates are based on duties paid that are collected by commodity. These commodities are assigned to industries based on the primary industry of production. Average tariffs are then calculated using import values as weights. U.S tariff rates are once again based on import duties by commodity, are assigned to an industry using the same Canadian concordance table used for Canadian commodity duties, and then aggregated based on U.S. import weights. These tariff rates were kindly supplied by Professor Trefler. The Canadian tariff rates were calculated by the International Trade Division of Statistics Canada to his specifications. Trefler calculates the U.S. tariff rates using data from Feenstra (1996).

Table A1. Summary statistics of variables in the sample for estimating the determinants of product diversification

Variables	Mean	Standard deviation
Plant diversification	0.244	0.268
Canadian tariff	0.056	0.059
U.S. tariff	0.029	0.037
Labour intensive sector	0.254	0.435
Natural resources sector	0.334	0.472
Scale-based sector	0.221	0.415
Product-differentiated sector	0.122	0.327
Science-based sector	0.070	0.255
Foreign-controlled plants	0.185	0.388
Plant size (log employment)	3.314	1.457
Young plants	0.260	0.439
Exporters	0.482	0.500
Multi-plant firm	0.368	0.482

Table A2. Summary statistics of variables in the sample used for estimating the effects of tariff changes

Variables	Mean	Standard deviation
Changes in plant diversification	-0.008	0.029
Tariff cuts	0.006	0.010
Relative plant diversification	-0.188	0.754
Foreign-controlled plants	0.294	0.456
Plant size (log employment)	4.427	1.180
Young plants	0.110	0.313
Multi-plant firm	0.597	0.491
Plant growth	0.002	0.076
Labour intensive sector	0.200	0.399
Natural resources sector	0.368	0.482
Scale-based sector	0.265	0.441
Product-differentiated sector	0.100	0.300
Science-based sector	0.067	0.251

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